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The Heteromorph Ammonite *Didymoceras cochleatum* (Meek and Hayden, 1858), from the Pierre Shale of South Dakota and Wyoming

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ABSTRACT

The middle Campanian (Upper Cretaceous) zone of *Baculites gregoryensis* Cobban, 1951 in south-central South Dakota and eastern Wyoming has yielded numerous fragments of a distinctive species of *Didymoceras* characterized by initial loose planispiral whorls followed by loose helical whorls, and finally by a slightly pendant body chamber. These fragments are referred to *Didymoceras cochleatum* (Meek and Hayden, 1858), a species based on one-half of a septate whorl from the helical growth stage. This species is abundant in the Gregory Member of the Pierre Shale along the Missouri River Valley in South Dakota, rare in the Red Bird Silty Member of the Pierre Shale in eastern Wyoming, and very rare in the Rock River Formation in southeastern Wyoming.

INTRODUCTION

Heteromorph ammonites of the genus *Didymoceras* Hyatt, 1894, are important guide fossils to some of the zones of *Baculites* in the Upper Cretaceous of the Western Interior. Among these heteromorph ammonites is the species *Didymoceras cochleatum* (Meek and Hayden, 1858), which occurs in the middle Campanian zone of *Baculites gregoryensis* Cobban, 1951, in the Gregory Member of the Pierre Shale along the Missouri River Valley in south-central South Dakota, in the Red Bird Silty Member of the Pierre Shale along the west flank of the Black Hills in eastern Wyoming, and in the Rock River Formation in southeastern Wyoming. For a review of the Campanian ammonite zonation in the

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Western Interior, the reader is referred to the original zonation by Cobban in Gill and Cobban (1966), and to the revised zonation by Cobban in Cobban et al. (1994), which includes the latest radiometric dates by John Obradovich.

LOCALITIES

All of the fossils described in this report come from two localities. The largest collection, made available for study by the Black Hills Museum of Natural History, Hill City, South Dakota, is from the Gregory Member of the Pierre Shale along the Missouri River below Fort Thompson, South Dakota. The other large collection is from septarian calcareous concretions a little above the middle of the Red Bird Silty Member of the Pierre Shale at U.S. Geological Survey (USGS) Mesozoic locality D1908 in the SE¼ sec. 14, T38N, R62W, Niobrara County, Wyoming (for geologic details, see Gill and Cobban, 1966).

SYSTEMATIC PALEONTOLOGY

Most of the fossils described in this report are reposited in the U.S. National Museum of Natural History (USNM), Washington, D.C. The rest of the specimens are reposited in the Black Hills Museum of Natural History (BHMNH), Hill City, South Dakota.

ORDER AMMONOIDEA ZITTEL, 1884
SUBORDER ANCYLOCERATINA WIEDMANN, 1966
SUPERFAMILY TURRILITACEAE GILL, 1871

Genus *Didymoceras* Hyatt, 1894

TYPE SPECIES: *Ancyloceras nebrascense* Meek and Hayden, 1856: 71, by original designation.

Didymoceras cochleatum (Meek and Hayden, 1858)

Figures 1–5

Turrilites (*Helicoceras*) Meek and Hayden, 1858: 55.
Helicoceras cochleatum Meek and Hayden. Meek and Hayden, 1860:421.
Helicoceras cochleatum Meek and Hayden. Meek, 1864:25.

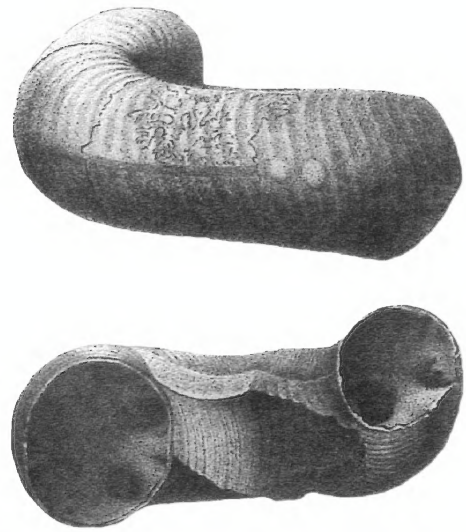

Fig. 1. Holotype (now lost) of *Didymoceras cochleatum* (Meek and Hayden, 1858) reproduced from Meek (1876: pl. 22, figs. 2a, b). Natural size.

Heteroceras? (sp. undt.) Meek, 1876: pl. 21, fig. 4a, b.
Heteroceras? *cochleatum* H. & M. Meek, 1876: 478, pl. 22, fig. 2a, b.
Turrilites (*Helicoceras*) *cochleatus* Meek and Hayden. Boyle, 1893:293.
Didymoceras (*Het.*) *cochleatum* Meek. Hyatt, 1894:574.
Heteroceras? *cochleatum* H. & M. Logan, 1898: 512, pl. 107, fig. 2.
Didymoceras cochleatum Meek sp. Spath, 1921: 253.
Turrilites (*Heteroceras*) *cochleatum* Meek and Hayden. Diener, 1925:90.
Didymoceras cochleatum (Meek and Hayden). Kennedy and Cobban, 1993a:135, pl. 1, figs. 29, 30; pl. 2, figs. 10–15; pl. 4, figs. 27–32; text-figs. 6C, 7C, 9C–H, 10C, D.
Didymoceras cochleatum (Meek and Hayden, 1858). Larson et al., 1997:52.

TYPE: The type specimen is lost (Meek, 1876:479). It was from the "Great Bend of the Missouri, below Fort Pierre, Dakota." According to our present knowledge, the specimen probably came from the Gregory Member of the Pierre Shale somewhere in the Fort Thompson area of South Dakota.

MATERIAL: There are approximately 150 specimens from the Gregory Member of the Pierre Shale near Fort Thompson and 11 incomplete specimens from the Red Bird Silty Member of the Pierre Shale in eastern Wy-

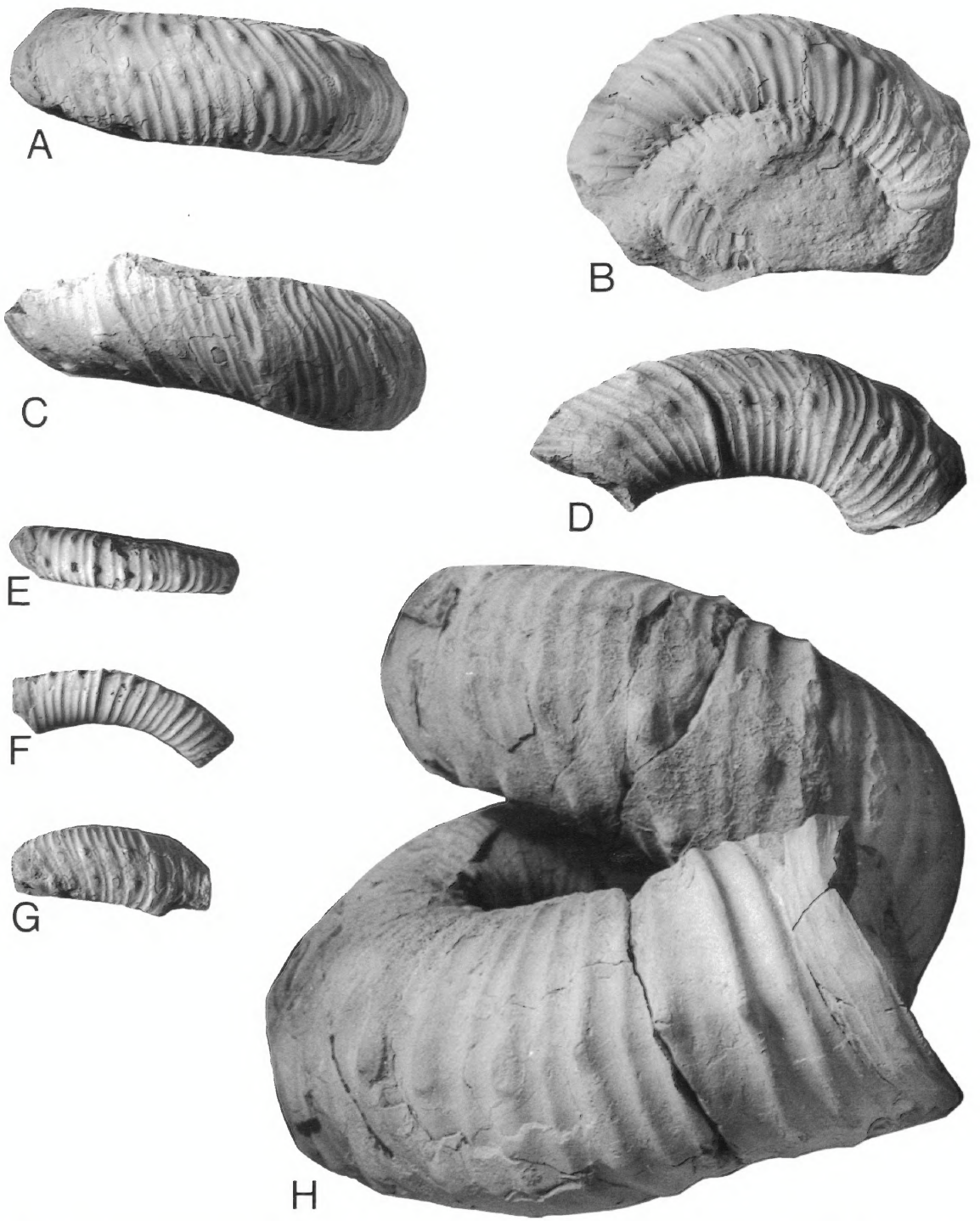

Fig. 2. *Didymoceras cochleatum* (Meek and Hayden, 1858). **A, B.** USNM 488803, one of Meek and Hayden's specimens from the Great Bend of the Missouri River in central South Dakota. **C, D.** USNM 488804, Gregory Member of the Pierre Shale in the Fort Thompson area in central South Dakota. **E, F.** USNM 488805, same locality as C and D. **G.** USNM 488806, same locality as C and D. **H.** USNM 488807, Red Bird Silty Member of the Pierre Shale, USGS Mesozoic locality D1908 in the SE 1/4 sec. 14, T38N, R62W, Niobrara County, Wyoming. All natural size.

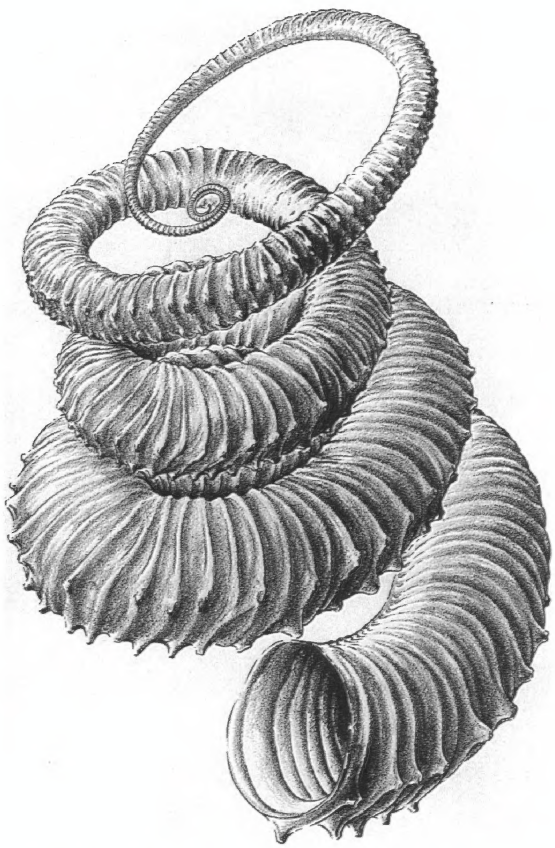

Fig. 3. Restoration of *Didymoceras cochleatum* (Meek and Hayden, 1858) by John R. Stacy. Drawing based on fragments from the Pierre Shale in Niobrara County, Wyoming. About ½ to ⅔ natural size.

oming. Specimens from the Gregory Member occur in clay ironstone concretions; most specimens are dark brown, limonitic internal molds, but some retain nacreous shell material. The smaller specimens are uncrushed, but the larger ones are mostly crushed. Specimens from the Red Bird Silty Member occur in highly septarian calcareous concretions and, accordingly, the specimens tend to be fragmented and to contain thick veins of calcite.

DIAGNOSIS: The initial whorls are coiled in an open planispire, followed by a large open elliptical whorl, which, in turn, is followed by two or three helical whorls that are not in contact; the final sector of the body chamber is slightly recurved. Ornament consists of fairly dense wirelike ribs that have small tubercles on every other or every third rib. One row of tubercles lies at mid-flank, and the other row lies near the base of the whorl. There are occasional constrictions.

DESCRIPTION: The type specimen (fig. 1) was little more than one-half of a helical septate whorl about 60 mm in diameter with a broad umbilicus about 22 mm in diameter (ratio of umbilical diameter to shell diameter = 0.37). The whorl section was subcircular. The rib index was about 9. Another specimen (fig. 2A, B) that was probably from Meek and Hayden's type lot is a little less than one-half whorl with a diameter of 60 mm and a whorl height of 19 mm at the midpoint of the fragment. The rib index is 8, and the ribs are somewhat irregular in height. There are small bullate tubercles on every second or third rib, and two weak constrictions are present.

A reconstruction of the species is shown in figure 3. The earliest growth stage is preserved in USNM 488813 (not illustrated); this and other fragments suggest an initial open coil of one or more planispiral whorls in close proximity, if not in contact; each whorl has a circular intercostal section. An initial sector of smooth shell is rapidly followed by one with ribbing. Ribs are coarse and narrower than the interspaces: the rib index is 4. The ribs are weakest on the dorsum, strengthen across the dorsolateral margin, and are strong, straight, and rectiradiate to feebly prorsiradiate on the flanks. About every other rib bears a sharp, septate ventral spine, represented by a flat-topped tubercle in worn specimens and internal molds.

This stage is succeeded by 1–1.5 whorls coiled in an open ellipse with a low translation rate, such that fragments are distinctly twisted when viewed ventrally (fig. 4C, D, F, G). The whorl section remains circular, with a rib index of 3–3.5. Ribs are weak and oblique on the dorsum, and are strong and narrow on the upper whorl face (fig. 4A), where they are separated by wider interspaces. They are weakly to markedly prorsiradiate, and about every other rib bears a strong spine/tubercle at the juncture of the upper and outer whorl faces. A blunt transverse rib, sometimes split into a pair of looped riblets, links each of these tubercles to a second row at the juncture of outer and lower whorl faces (fig. 2A). These tubercules give rise to

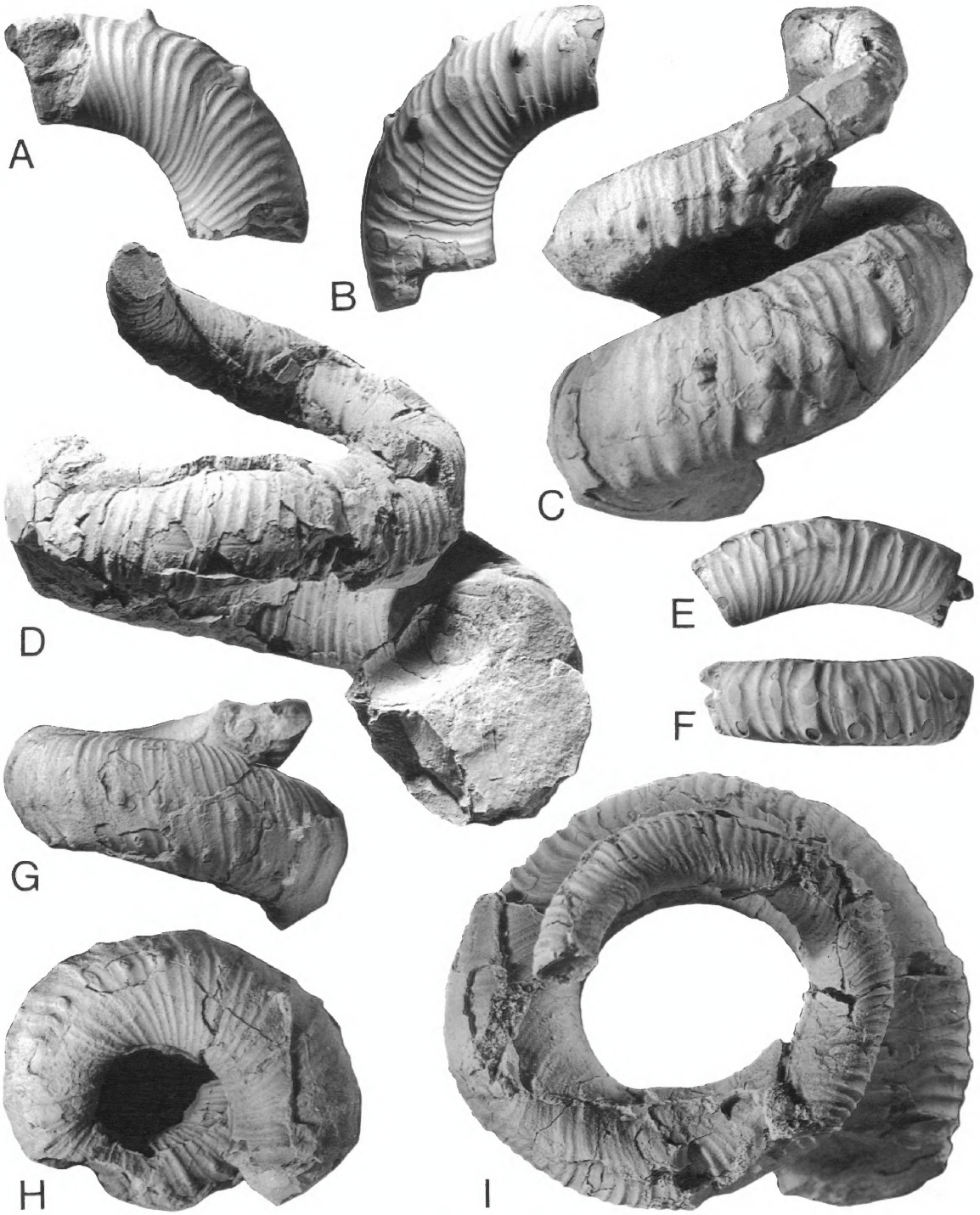

Fig. 4. *Didymoceras cochleatum* (Meek and Hayden, 1858). **A, B.** USNM 488808, Gregory Member of the Pierre Shale in the Fort Thompson area in central South Dakota. **C.** USNM 488809, Red Bird Silty Member of the Pierre Shale, USGS Mesozoic locality D1908 in the SE 1/4 sec. 14, T38N, R62W, Niobrara County, Wyoming. **D, I.** USNM 488810, same locality as C. **E, F.** USNM 488811, same locality as A and B. **G, H.** USNM 488812, same locality as C. All natural size.

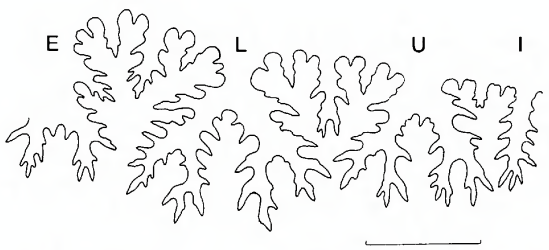

Fig. 5. Suture of *Didymoceras cochleatum* (Meek and Hayden, 1858) at a whorl height of 12.6 mm. BHMNH 4071, Gregory Member of the Pierre Shale in the Fort Thompson area, South Dakota. **E** is the external lobe, **L** is the lateral lobe, **U** is the umbilical lobe, and **I** is the internal lobe. Scale bar is 5 mm.

strong, straight to weakly convex rursiradiate ribs on the lower whorl face.

The following 2–2.5 whorls form a more regular helix with a circular whorl section (figs. 3, 4G, H). Ornament becomes progressively more complex. Ribs are weak and slightly convex on the inner whorl face, strengthen and sweep back on the upper whorl face, then bend forward over the juncture of upper and outer whorl faces, where they are markedly concave. Ribs are strong, straight, and prorsiradiate on the outer whorl face, bearing septate spines/flat-topped tubercles (depending on preservation) at mid-flank. In most specimens only a single rib links to each tubercle, but in a few specimens ribs link in pairs (figs. 2C, 4F), and there are some nontuberculate ribs as well (figs. 2A–C, 4B, F). Single ribs, more rarely pairs of ribs, connect to a second row of spines/tubercles displaced aperturally, and lying at the juncture of outer and lower whorl faces; ribs also may zig-zag between tubercles. Each tubercle in the lower row gives rise to one or two coarse ribs which, with the intercalated ribs, are straight or slightly convex and markedly rursiradiate on the lower whorl face; they decline progressively toward the umbilicus (figs. 2B, D, 4B). Occasional weak constrictions are usually bordered by high or thickened ribs (figs. 2C, D).

The final sector of the last whorl shows an increase in translation rate, detaching from the spire. The body chamber occupies the last part of the final whorl of the helix and is slightly distended (figs. 2H, 3). The aperture follows the form of the ribs (fig. 2H). Sutures are poorly preserved but are typical of the genus (fig. 5).

DISCUSSION: *Didymoceras cochleatum* differs from *Didymoceras stevensoni* (Whitfield, 1877)—see Whitfield, 1880: 447, pl. 14, figs. 5–8; reconstructions in Scott and Cobban, 1965, and Gill and Cobban, 1973—in that *D. stevensoni* shows coarser ribbing, a middle helical growth stage in which the whorls are in contact, and a longer U-shaped final sector of the body chamber, with the plane of the U oriented parallel to the axis of coiling of the helix. *Didymoceras nebrascense* (Meek and Hayden, 1856)—see reconstructions in Scott and Cobban, 1965, Gill and Cobban, 1973, and Kennedy and Cobban, 1976—is a larger species, with hamitid early whorls and a long U-shaped body chamber. Ribbing is much finer than in *D. cochleatum*. *Didymoceras cheyennense* (Meek and Hayden, 1856) (see reconstructions in the above references) resembles *D. cochleatum* in its loose helix and ornament but the last part of the body chamber is a long U in *D. cheyennense*, quite unlike the adult body chamber of *D. cochleatum*. *Didymoceras cochleatum* differs from *Didymoceras binodosum* Kennedy and Cobban (1993) in having a more loosely coiled shell and less distinct constrictions (Kennedy and Cobban, 1993b).

OCCURRENCE: In addition to the records from eastern Wyoming and south-central South Dakota, *D. cochleatum* occurs at several localities in the Pierre Shale in Colorado. The species also occurs in the Annona Chalk in Arkansas.

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